

Do The Particles With Nonzero Mass Need Duality ?

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Abstract

Unsufficiency of conditions for the formation of interference in monoparticle "which path" experiments is proven. The version of corpuscular interpretation of diffraction pattern based on the action discreteness is presented, which makes unnecessary to accredit duality to the particles with nonzero mass. The experiment to check the above mentioned concepts are proposed.

1. Introduction.

Interpreting all the "which path" experimental data one usually proceeds from the fact that the observed irregularities at single microparticle diffraction have interferential origin in spite of the lack of strictly definitive experimental evidence. The resemblance of diffraction pattern in multiphoton (classical optics) and monophoton experiments may appear a scanty proof of interference presence in the latter case.

It is an axiom that simultaneous arrival of at least two monochromatic and coherent waves to the observation point is an obligatory condition for the formation of interference. Observing no second wave in monophoton (monoparticle) experiments and basing on the generally accepted understanding of the interferential origin of mentioned irregularities most of the researchers were forced to assume the interference of a single particle (photon) with itself by its violent simultaneous pulling through both slits separated with spatial distance by several orders longer (by the order of 4 for the experiments with atoms of helium [1]) than the transverse sizes of these particles. Meanwhile, the particles do not undergo fission: no loss of microparticle energy or photon frequency is observed behind the slits.

This paper shows that the registered irregularities in monoparticle (monophoton) "which path" experiments may not have interferential origin due to the insufficiency

conditions for the interference realization (two waves as minimum). This is why the attempts to interpret diffraction pattern in monophoton (monoparticle) experiments using interference (maybe only seeming) bring to well-known logical contradictions or, according Feynman, to a puzzle [2].

In order to discover a logical hitch and to provide obligatory conditions for the interference we are forced using superposition principle and diffraction grating to fission a single photon into two ones [3], ignoring the law of conservation of energy and other quantum numbers (lepton and hadron numbers in case of diffraction of electrons, nucleons and nuclei).

The only one way out of this logical deadlock is may seem to withdraw seeming interference because of scanty conditions for its realization in the monoparticle "which path" experiments and to search for new mechanisms of origin of detected irregularities from the corpuscular point of view by analogy to photo- and Compton-effects, when one has to use corpuscular representations, although nobody doubts in the wave properties of photons.

2. The version of corpuscular interpretation.

In our recent publication [3] a brief description of this interpretation is given. Due to the importance of the problem we are giving below more detailed presentation.

In the diffraction experiments the corpuscular-field interactions of microparticles with matter of grating are not taken into account. Only the wave-diffractive aspects are regarded. Such approach is acceptable in the classical optics, where out of a huge flux of photons simultaneously dropping on the diffraction grating, two or more photons will appear, which passed through the different slits. Meeting each other they will interfere here among themselves. Although in this case the mechanism of light beam deflection from the initial direction is not clear enough without accounting of Huygens-Fresnel approximate model, which should be corrected in the light of corpuscular presentation. Quite different situation is observed, when a single photon, which may interfere only with itself (a puzzle!) [2] falls on two slits with $b \gg \lambda$ (b is the distance between the slits and λ is the length of photon wave).

In order to understand why the corpuscular-field interpretation is the only correct

way out to solve the puzzle we shall present the experimental results. The possibility of diffractive scattering of electrons and neutrons with the identical de Broglie wave lengths at one and the same crystal differs by the order of ~ 7 to the electrons. The electron interacts with the crystal through Coulomb field, while the neutron - mainly through the short-range nuclear forces. Such substantial difference at the same λ/b proportions shows the dominant importance of corpuscular-field interactions as compared with the wave-diffractive ones.

The account of microparticle interaction with the grating matter becomes more simple, if we accept the action multiplicity from the Planck constant (h) for the non-bound states as well. This hypothesis has no heuristical value. It is used for a long time in non-explicit form in theoretical analysis of microparticle scattering angular distribution using the method of partial waves [4] in the form of discreteness angular momentum having dimension of action.

The discrete behaviour of the action is natural because of the fact, that the non-bound state may differ in principle from its analogue in bound state in as less "surplus" as the kinetic energy. The nature is hardly arranged in the manner, when, e.g. at Coulomb interaction of electron with proton in hydrogen atoms the action is quantized, while at Coulomb scattering of the same particles one over another near to kinematic region of hydrogen atoms the action will not be quantized.

Let a parallel beam of microparticles with P momentum falls on the crystal with b period and as a result of elastic scattering obtains P_r transverse momentum. The scattering angle θ is determined by the relation

$$P \sin \theta = P_r . \quad (1)$$

It is necessary to find out P_r from the following differential equation

$$d\vec{P}_r = \vec{F}_r dt \quad (2)$$

where F_r is the force acting on the particle from the crystal in the direction perpendicular to the beam. Scalaraly multiplying [2] by $d\vec{r}$ of path in \vec{F}_r direction we shall receive

$$d\vec{P}_r \cdot d\vec{r} = \vec{F}_r \cdot d\vec{r} \cdot dt = dS_r(r, t) \quad (3)$$

where dS_r - is the action in \vec{F}_r direction of path $d\vec{r}$ in dt time period.

In order to receive complete action during t time when the particle is in crystal it is necessary to define the integration limits of r and t variables. Choosing the limits for r from 0 to b and for the time period from 0 to t the equation (3) may be rewritten as

$$\int_0^t dP_r \int_0^b dr = \int_0^t \int_0^b dS_r(r, t) \quad (4)$$

With the account that the right side is the complete action and, as we suppose, should be equal to the multiple of Planck constant h , we may have

$$P_r \cdot b = nh \quad (5)$$

If we substitute from here the value P_r in (1), we shall receive

$$b \cdot \sin \theta = n \cdot h/P = n\lambda \quad (6)$$

where $\lambda = h/P$. The formula (6) shows, that the quantitative agreement with de Broglie hypothesis observed in the experiment is not accidental. The de Broglie hypothesis contains in a latent form our hypothesis [3] about the action discreteness of h in all types of interactions. Due to the latter fact, as it may be seen from (6), the diffraction scattering angles θ obtain discrete values, imitating interferential pattern. The corpuscular-field interpretation, which leads to the same quantitative results as the de Broglie wave diffractive representations, allows to avoid generally known logical difficulties [2] at the interpretation of the diffractive pattern. This removes the discussed contradictions [3] of the superposition principle to the assumption of interference in the monoparticle "which path" experiments. This principle is apparently is not acceptable in the case of alternative and mutually transitional in time states, such as the transition of a single particle either through the first or the second slit. Such events are unable to interfere due to the absence of partner. The composition of their probability amplitudes is impossible, because they will compose the mixture combination of the probabilities.

3. Expected experimental evidences.

3.1. The analysis of existing experiments.

In [3] we have proposed the real version of two slit Young type experiment [1], capable to give the conclusive description of the effect of open slit, that has not passed by

microparticle, on its behaviour. It is proposed to compare the diffraction pattern of two open slits with a total picture, when either one or another slit opens in its turn. In the total exposure the interference must not appear by definition.

It is easy to propose that under $b \gg \lambda$ conditions the pattern with two open slits will be identical to the total picture, as far as the single microparticle will pass through one of two slits, while the other slit, which is not passed, may be at that moment considered as closed. Hence, the interference should be not possible at two slits either in the experiments with single particles. While the irregularities observed in [1, 5, 6] may be interpreted by the formula (6). However, this does not mean that the experiment should not be done. It will finally prove what is correct.

3.2. New possible experiments.

In order to prove the impossibility of a single microparticle transit through two slits (and therefore the impossibility of interference) we propose the experiment based on the Young scheme (or its analogy). Let us dispose detectors one by one after each slit and direct their signals to the coincidence scheme. The absence of coincidence signals will evidence of the impossibility of simultaneous passing of a single particle through the both slits, while the existence of such signals will prove the opposite concept.

Let us discuss the scheme of one more experiment. The parallel beam of coherent photons using semitransparent mirror is fissioned into two parts: reflected and transmitted ones. Arranging the meeting of these two parts we shall see the interferential picture.

Then using the optical filter we create out of multiphoton beam a single photon beam with $t_m \ll t_c$ parameters, where t_m is a mean time interval between neighbour photons and t_c is the train duration. In this case there will be no interference, because the photons will enter the observation zone at different times.

This one and two slit Young type experiments have the same origin. In both cases the photon has two possible unpredictable paths. The advantage of such version, based on the absence of the interference imitation conditioned on formula (6), will serve as a touchstone for the corpuscular interpretation [3] of diffraction pattern, in contrast to the previous tests, when only the legitimacy (correctness) of the wave representations (interpretations) could be resolved.

Conclusion.

The causality principle excludes the emergence of interference in the single particle (monophoton) "which path" experiments. Proceeding from this it is impossible to interpret the irregularities observed in these experiments using wave representations. They are likely to be connected with the discreteness of action and for non-bound states.

The experiment according the described schemes are necessary in order to prove the correctness of the proposed fundamental statement together with corpuscular interpretation.

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